
io-port 00048934**Martz, Harry F.; Waller, Ray A.****Bayesian reliability analysis. Reprint with corrections of the 1982 Orig., publ. by John Wiley & Sons.**

Malabar, FL: Krieger Publishing Company. xix, 745 p. (1991).

[For the review of the original 1982-edition see Zbl 0597.62101.] This book presents Bayesian methods for analysis of reliability data. It provides a coverage of Bayesian methods developed upto early 1980's. The book can be thought as organized into four parts. The first part (Chapters 1, 2 and 3) provides a review of probability and statistics concepts; the second part (Chapters 4, 5 and 6) presents an introduction to reliability concepts and an introduction to Bayesian inference; the third part (Chapters 7, 8 and 9) discusses Bayesian inference for failure rate and reliability estimation for different life models and the final part (Chapters 10 through 13) focusses on more specialized topics such as reliability demonstration testing, system reliability assessment, availability estimation and empirical Bayes methods for reliability. The book presents a large number of examples that illustrate the use of Bayesian methods. There are appendices presenting a summary of commonly used probability distributions, statistical tables and tables that are helpful in specifying prior parameters for some distributions. In Chapter 1, the authors present the purpose and scope of the book and emphasize the importance and advantages of Bayesian methods in reliability analysis. Chapter 2 presents an introduction to probability theory, laws of probability, and discrete and continuous probability models. Chapter 3 discusses moments, transformation of random variables, moment generating functions and introduces sampling distributions and classical (frequentist) estimation techniques. A review of point estimation techniques such as maximum likelihood and method of moments as well as interval estimation and hypothesis testing are also given in Chapter 3. Examples from reliability analysis and life testing are used to illustrate the use of these techniques. The chapter also discusses the likelihood-ratio and goodness of fit tests. In Chapter 4, the authors introduce fundamental notions of reliability. Basic definitions of terms such as reliability function, mean time to failure, hazard rate and reliable life are given and concepts, that are related to system effectiveness, such as availability, maintainability and repairability are discussed. Commonly used life models in reliability analysis such as exponential, Weibull, lognormal, gamma, etc. are discussed and their properties as well as reliability measures are introduced. This chapter discusses also classical model selection via nonparametric hazard rate estimation, total time on test plots and probability plots. Furthermore, this chapter introduces life testing and uses the exponential model to present classical estimation and hypothesis testing. It also discusses classical approaches for reliability demonstration and system reliability assessment using the exponential model. Chapter 5 introduces the Bayesian view and its foundations. The subjective interpretation of probability is introduced and the differences between the classical and Bayesian views are discussed. The authors discuss the notion of prior distribution, likelihood function and Bayesian updating and emphasize the advantages of Bayesian inference in reliability analysis. This chapter presents also the Bayesian decision theory and point estimation under specific loss functions. Bayesian estimation based on sufficient statistics, interval estimation and the concept of highest posterior density intervals are also discussed here. In Chapter 6, the authors present the notions of conjugate and noninformative priors as well as the maximum entropy priors. This chapter addresses also encoding subjective probabilities and developing consensus prior distributions. Methods for specifying the forms of particular prior distributions are discussed. Chapter 7 discusses Bayesian estimation where the life test data is of attribute form. The binomial, Pascal and Poisson sampling situations are considered. Bayesian point and interval estimates are presented under the binomial and Pascal sampling using conjugate beta/uniform priors as well as using noninformative priors. For the Poisson case, Bayesian estimates are developed using various forms of priors for the failure rate; these include uniform, gamma, lognormal, Weibull and noninformative priors. Numerical methods are used for some of the cases where inference can not be obtained in closed form. In Chapter 8, the authors discuss Bayesian inference for the exponential model based on complete and censored life tests. The authors present Bayesian failure rate estimation using various prior distributions for the failure rate including the (conjugate) gamma, uniform and noninformative priors and discuss point and interval estimation. Similarly, inference for the mean time to failure is developed using different priors as well as linear Bayesian estimation that uses the first two moments for posterior updating. Reliability estimation is also considered in this chapter using beta, uniform and noninformative priors. Finally, Bayesian inference for the two-parameter exponential model (with a threshold parameter) is considered using conjugate and noninformative prior distributions. In Chapter 9, the Bayesian framework of Chapter 8 is extended to other life models. Bayesian inference for the more flexible Weibull model is introduced when both the shape and scale parameters are unknown. Closed form expressions are obtained only in the case where a gamma prior is considered for the scale and a discrete prior is assumed for the shape parameter. For any other forms of prior considered for the shape parameter, estimation results are based on numerical integration techniques. The

authors discuss also Bayesian estimation of mean time to failure and reliability using numerical methods. Bayesian inference for normal, lognormal, inverse Gaussian and gamma life models are also discussed in this chapter. Using conjugate priors in normal and lognormal models, the posterior distribution of the parameters are obtained in tractable forms whereas the reliability and failure rate estimation require some numerical evaluations. For the gamma life model where both the shape and scale parameters are unknown, the Bayesian estimation requires numerical integration. In Chapter 10, the problem of reliability demonstration testing is considered from a Bayesian perspective introducing Bayes risk. Bayesian plans for reliability demonstration tests are discussed for attribute data. Test plans for the exponential model with unknown mean life are also discussed and Bayesian and classical situations are compared. Sequential Bayesian reliability demonstration tests are introduced in this chapter for attribute data and the expected sample sizes and risk evaluations are presented. The authors present Bayesian system reliability assessment in Chapter 11. They introduce the notion of coherent systems and discuss the series, parallel and r -out-of- k systems. Given life testing data on individual components, the posterior system reliability assessment is made by use of Mellin integral transforms and point and interval estimates for system reliability are obtained. Both the attribute data and exponential life length data cases are discussed. The authors also develop system reliability assessment based on system test data. These are applied to the series, parallel and r -out-of- k systems using both attribute and exponential life length data. More complex systems that are mixtures of parallel and series systems are also considered in this chapter and a Monte Carlo approach is presented. In Chapter 12, Bayesian assessment of system availability is considered. Concepts of availability and steady-state availability are discussed and Bayesian point and interval estimation are introduced for component and system availability for general failure/repair times. Results are also obtained for exponential failure/repair times for series and parallel systems. Extension to exponential failure and gamma repair times is considered. Bayesian reliability estimation of periodically maintained systems is also discussed and point and interval estimates for system reliability are obtained for systems with redundancy. In Chapter 13, the authors discuss use of empirical Bayes techniques in reliability estimation. This chapter presents an overview of the empirical Bayes decision theory and discusses the basics of empirical Bayesian estimation. A general framework is introduced for empirical Bayes point estimation and smoothing of empirical Bayes estimators discussed. Probability density estimation is also presented in this chapter and interval estimation using empirical Bayes methods are illustrated. The framework and the methods are then used in reliability estimation for both attribute and variable data cases. Failure rate estimation in Poisson sampling and reliability estimation in Weibull, gamma, and lognormal models using empirical Bayes methods are discussed. Point and interval estimates are obtained for these parameters. R.Soyer

Keywords: sequential Bayesian reliability demonstration tests; life testing; likelihood-ratio; goodness of fit tests; reliability function; mean time to failure; hazard rate; reliable life; availability; maintainability; repairability; reliability measures; model selection; nonparametric hazard rate estimation; total time on test plots; probability plots; exponential model; Bayesian updating; sufficient statistics; interval estimation; highest posterior density intervals; noninformative priors; maximum entropy priors; consensus prior distributions; binomial; Poisson sampling; Pascal sampling; censored life tests; failure rate estimation; linear Bayesian estimation; Weibull model; gamma prior; numerical integration techniques; conjugate priors; lognormal models; attribute data; Bayesian system reliability assessment; coherent systems; r -out-of- k systems; Mellin integral transforms; Monte Carlo approach; steady-state availability; periodically maintained systems; redundancy; smoothing of empirical Bayes estimators; density estimation